SCIENCE

A WEEKLY JOURNAL DEVOTED TO THE ADVANCEMENT OF SCIENCE, PUBLISHING THE OFFICIAL NOTICES AND PROCEEDINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

FRIDAY, AUGUST 25, 1905.

CONTENTS.

Address of the President of the British Association for the Advancement of Science: PROFESSOR G. H. DARWIN 225

Address to the Mathematical and Physical Section of the British Association for the Advancement of Science: PROFESSOR A. R. FORSYTH 234

Scientific Books:—

Catalogue of the Lepidoptera Phalænæ in the British Museum: DR. HARRISON G. DYAR 247

Scientific Journals and Articles 248

Societies and Academies:—

Clemson College Science Club: DR. HAVEN METCALF 248

Special Articles.—

Assortative Mating in Man: DR. FRANK E. LUTZ 249

Current Notes on Meteorology:—

Progress of Kite and Balloon Meteorology; Meteorological Activity in England; Tropical Cyclones; Climatic Changes in Central Africa; Cotton-growing in Tropical Australia; Hurricanes, Cocoa Trees and Exports of Guam; Exposure and Crops in Switzerland: PROFESSOR R. DEC. WARD ... 250

Acta of the International Convention of the International Catalogue of Scientific Literature 252

Scientific Notes and News 253

University and Educational News 256

MSS. intended for publication and books, etc., intended for review should be sent to the Editor of SCIENCE, Garrison-on-Hudson, N. Y.

ADDRESS OF THE PRESIDENT OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.[1]

I.

BARTHOLOMEU DIAZ, the discoverer of the Cape of Storms, spent sixteen months on his voyage, and the little flotilla of Vasco da Gama, sailing from Lisbon on July 8, 1497, only reached the Cape in the middle of November. These bold men, sailing in their puny fishing-smacks to unknown lands, met the perils of the sea and the attacks of savages with equal courage. How great was the danger of such a voyage may be gathered from the fact that less than half the men who sailed with da Gama lived to return to Lisbon. Four hundred and eight years have passed since that voyage, and a ship of 13,000 tons has just brought us here, in safety and luxury, in but little more than a fortnight.

How striking are the contrasts presented by these events! On the one hand compare the courage, the endurance and the persistence of the early navigators with the little that has been demanded of us; on the other hand consider how much man's power over the forces of nature has been augmented during the past four centuries. The capacity for heroism is probably undiminished, but certainly the occasions are now rarer when it is demanded of us. If we are heroes, at least but few of us ever find it out, and, when we read stories of ancient feats of courage, it is hard to prevent an uneasy thought that, notwithstanding our

[1] Cape Town, August 15, 1905.

boasted mechanical inventions, we are perhaps degenerate descendants of our great predecessors.

Yet the thought that to-day is less romantic and less heroic than yesterday has its consolation, for it means that the lot of man is easier than it was. Mankind, indeed, may be justly proud that this improvement has been due to the successive efforts of each generation to add to the heritage of knowledge handed down to it by its predecessors, whereby we have been born to the accumulated endowment of centuries of genius and labor.

I am told that in the United States the phrase 'I want to know' has lost the simple meaning implied by the words, and has become a mere exclamation of surprise. Such a conventional expression could hardly have gained currency except amongst a people who aspire to knowledge. The dominance of the European race in America, Australasia and South Africa has no doubt arisen from many causes, but amongst these perhaps the chief one is that not only do 'we want to know,' but also that we are determined to find out. And now within the last quarter of a century we have welcomed into the ranks of those who 'want to know' an oriental race, which has already proved itself strong in the peaceful arts of knowledge.

I take it, then, that you have invited us because you want to know what is worth knowing; and we are here because we want to know you, to learn what you have to tell us, and to see that South Africa of which we have heard so much.

The hospitality which you are offering us is so lavish, and the journeys which you have organized are so extensive, that the cynical observer might be tempted to describe our meeting as the largest picnic on record. Although we intend to enjoy our picnic with all our hearts, yet I should like to tell the cynic, if he is here, that perhaps the most important object of these conferences is the opportunity they afford for personal intercourse between men of like minds who live at the remotest corners of the earth.

We shall pass through your land with the speed and the voracity of a flight of locusts; but, unlike the locust, we shall, I hope, leave behind us permanent fertilization in the form of stimulated scientific and educational activity. And this result will ensue whether or not we who have come from Europe are able worthily to sustain the lofty part of prophets of science. We shall try our best to play to your satisfaction on the great stage upon which you call on us to act, and if when we are gone you shall, amongst yourselves, pronounce the performance a poor one, yet the fact will remain, that the meeting has embodied in a material form the desire that the progress of this great continent shall not be merely material; and such an aspiration secures its own fulfilment. However small may be the tangible results of our meeting, we shall always be proud to have been associated with you in your efforts for the advancement of science.

We do not know whether the last hundred years will be regarded forever as the *sæculum mirabile* of discovery, or whether it is but the prelude to yet more marvelous centuries. To us living men, who scarcely pass a year of our lives without witnessing some new marvel of discovery or invention, the rate at which the development of knowledge proceeds is truly astonishing; but from a wider point of view the scale of time is relatively unimportant, for the universe is leisurely in its procedure. Whether the changes which we witness be fast or slow, they form a part of a long sequence of events which begin in some past of immeasurable remoteness and tend

to some end which we can not foresee. It must always be profoundly interesting to the mind of man to trace successive cause and effect in the chain of events which make up the history of the earth and all that lives on it, and to speculate on the origin and future fate of animals, and of planets, suns and stars. I shall try, then, to set forth in my address some of the attempts which have been made to formulate evolutionary speculation. This choice of a subject has, moreover, been almost forced on me by the scope of my own scientific work, and it is, I think, justified by the name which I bear. It will be my fault and your misfortune if I fail to convey to you some part of the interest which is naturally inherent in such researches.

The man who propounds a theory of evolution is attempting to reconstruct the history of the past by means of the circumstantial evidence afforded by the present. The historian of man, on the other hand, has the advantage over the evolutionist in that he has the written records of the past on which to rely. The discrimination of the truth from amongst discordant records is frequently a work demanding the highest qualities of judgment; yet when this end is attained it remains for the historian to convert the arid skeleton of facts into a living whole by clothing it with the flesh of human motives and impulses. For this part of his task he needs much of that power of entering into the spirit of other men's lives which goes to the making of a poet. Thus the historian should possess not only the patience of the man of science in the analysis of facts, but also the imagination of the poet to grasp what the facts have meant. Such a combination is rarely to be found in equal perfection on both sides, and it would not be hard to analyze the works of great historians so as to see which quality was predominant in each of them.

The evolutionist is spared the surpassing difficulty of the human element, yet he also needs imagination, although of a different character from that of the historian. In its lowest form his imagination is that of the detective who reconstructs the story of a crime; in its highest it demands the power of breaking loose from all the trammels of convention and education, and of imagining something which has never occurred to the mind of man before. In every case the evolutionist must form a theory for the facts before him, and the great theorist is only to be distinguished from the fantastic fool by the sobriety of his judgment—a distinction, however, sufficient to make one rare and the other only too common.

The test of a scientific theory lies in the number of facts which it groups into a connected whole; it ought besides to be fruitful in pointing the way to the discovery and coordination of new and previously unsuspected facts. Thus a good theory is in effect a cyclopedia of knowledge, susceptible of indefinite extension by the addition of supplementary volumes.

Hardly any theory is all true, and many are not all false. A theory may be essentially at fault and yet point the way to truth, and so justify its temporary existence. We should not, therefore, totally reject one or other of two rival theories on the ground that they seem, with our present knowledge, mutually inconsistent, for it is likely that both may contain important elements of truth. The theories of which I shall have to speak hereafter may often appear discordant with one another according to our present lights. Yet we must not scruple to pursue the several divergent lines of thought to their logical conclusions, relying on future discovery to eliminate the false and to reconcile together the truths which form part of each of them.

In the mouths of the unscientific evolu-

tion is often spoken of as almost synonymous with the evolution of the various species of animals on the earth, and this again is sometimes thought to be practically the same thing as the theory of natural selection. Of course those who are conversant with the history of scientific ideas are aware that a belief in the gradual and orderly transformation of nature, both animate and inanimate, is of great antiquity.

We may liken the facts on which theories of evolution are based to a confused heap of beads, from which a keen-sighted searcher after truth picks out and strings together a few which happen to catch his eye, as possessing certain resemblances. Until recently, theories of evolution in both realms of nature were partial and discontinuous, and the chains of facts were correspondingly short and disconnected. At length the theory of natural selection, by formulating the cause of the divergence of forms in the organic world from the parental stock, furnished the naturalist with a clue by which he examined the disordered mass of facts before him, and he was thus enabled to go far in deducing order where chaos had ruled before, but the problem of reducing the heap to perfect order will probably baffle the ingenuity of the investigator forever.

So illuminating has been this new idea that, as the whole of nature has gradually been reexamined by its aid, thousands of new facts have been brought to light, and have been strung in due order on the necklace of knowledge. Indeed, the transformation resulting from the new point of view has been so far-reaching as almost to justify the misapprehension of the unscientific as to the date when the doctrines of evolution first originated in the mind of man.

It is not my object, nor indeed am I competent, to examine the extent to which the theory of natural selection has needed modification since it was first formulated by my father and Wallace. But I am surely justified in maintaining that the general principle holds its place firmly as a permanent acquisition to modes of thought.

Evolutionary doctrines concerning inanimate nature, although of much older date than those which concern life, have been profoundly affected by the great impulse of which I have spoken. It has thus come about that the origin and history of the chemical elements and of stellar systems now occupy a far larger space in the scientific mind than was formerly the case. The subject which I shall discuss to-night is the extent to which ideas parallel to those which have done so much towards elucidating the problems of life, hold good also in the world of matter; and I believe that it will be possible to show that in this respect there exists a resemblance between the two realms of nature, which is not merely fanciful. It is proper to add that as long ago as 1873 Baron Karl du Prel discussed the same subject from a similar point of view, in a book entitled 'The Struggle for Life in the Heavens.'[1]

Although inanimate matter moves under the action of forces which are incomparably simpler than those governing living beings, yet the problems of the physicist and the astronomer are scarcely less complex than those which present themselves to the biologist. The mystery of life remains as impenetrable as ever, and in his evolutionary speculations the biologist does not attempt to explain life itself, but, adopting as his unit the animal as a whole, discusses its relationships to other animals and to the surrounding conditions. The physicist, on the other hand, is irresistibly impelled to form theories as to the intimate

[1] *Der Kampf um's Dasein am Himmel* (zweite Auflage), Denicke, Berlin, 1876.

constitution of the ultimate parts of matter, and he desires further to piece together the past histories and the future fates of planets, stars and nebulæ. If then the speculations of the physicist seem in some respects less advanced than those of the biologist, it is chiefly because he is more ambitious in his aims. Physicists and astronomers have not yet found their Johannesburg or Kimberley; but, although we are still mere prospectors, I am proposing to show you some of the dust and diamonds which we have already extracted from our surface mines.

The fundamental idea in the theory of natural selection is the persistence of those types of life which are adapted to their surrounding conditions, and the elimination by extermination of ill-adapted types. The struggle for life amongst forms possessing a greater or less degree of adaptation to slowly varying conditions is held to explain the gradual transmutation of species. Although a different phraseology is used when we speak of the physical world, yet the idea is essentially the same.

The point of view from which I wish you to consider the phenomena of the world of matter may be best explained if, in the first instance, I refer to political institutions, because we all understand, or fancy we understand, something of politics, whilst the problems of physics are commonly far less familiar to us. This illustration will have a further advantage in that it will not be a mere parable, but will involve the fundamental conception of the nature of evolution.

The complex interactions of man with man in a community are usually described by such comprehensive terms as the state, the commonwealth, or the government. Various states differ widely in their constitution and in the degree of the complexity of their organization, and we classify them by various general terms, such as autocracy, aristocracy or democracy, which express somewhat loosely their leading characteristics. But, for the purpose of showing the analogy with physics, we need terms of wider import than those habitually used in politics. All forms of the state imply inter-relationship in the actions of men, and action implies movement. Thus the state may be described as a configuration or arrangement of a community of men; or we may say that it implies a definite mode of motion of man—that is to say an organized scheme of action of man on man. Political history gives an account of the gradual changes in such configurations or modes of motion of men as have possessed the quality of persistence or of stability to resist the disintegrating influence of surrounding circumstances.

In the world of life the naturalist describes those forms which persist as species; similarly the physicist speaks of stable configurations or modes of motion of matter; and the politician speaks of states. The idea at the base of all these conceptions is that of stability, or the power of resisting disintegration. In other words, the degree of persistence or permanence of a species, of a configuration of matter or of a state depends on the perfection of its adaptation to its surrounding conditions.

If we trace the history of a state we find the degree of its stability gradually changing, slowly rising to a maximum, and then slowly declining. When it falls to nothing a revolution ensues, and a new form of government is established. The new mode of motion or government has at first but slight stability, but it gradually acquires strength and permanence, until in its turn the slow decay of stability leads on to a new revolution.

Such crises in political history may give

rise to a condition in which the state is incapable of perpetuation by transformation. This occurs when a savage tribe nearly exterminates another tribe and leads the few survivors into slavery; the previous form of government then becomes extinct.

The physicist, like the biologist and the historian, watches the effect of slowly varying external conditions; he sees the quality of persistence or stability gradually decaying until it vanishes, when there ensues what is called, in politics, a revolution.

These considerations lead me to express a doubt whether biologists have been correct in looking for continuous transformation of species. Judging by analogy we should rather expect to find slight continuous changes occurring during a long period of time, followed by a somewhat sudden transformation into a new species, or by rapid extinction. However this may be, when the stability of a mode of motion vanishes, the physicist either finds that it is replaced by a new persistent type of motion adapted to the changed conditions, or perhaps that no such transformation is possible and that the mode of motion has become extinct. The evanescent type of animal life has often been preserved for us, fossilized in geological strata; the evanescent form of government is preserved in written records or in the customs of savage tribes; but the physicist has to pursue his investigations without such useful hints as to the past.

The time-scale in the transmutation of species of animals is furnished by the geological record, although it is not possible to translate that record into years. As we shall see hereafter, the time needed for a change of type in atoms or molecules may be measured by millionths of a second, while in the history of the stars continuous changes occupy millions of years. Notwithstanding this gigantic contrast in speed the process involved seems to be essentially the same.

It is hardly too much to assert that, if the conditions which determine stability of motion could be accurately formulated throughout the universe, the past history of the cosmos and its future fate would be unfolded. How indefinitely far we stand removed from such a state of knowledge will become abundantly clear from the remainder of my address.

The study of stability and instability then furnishes the problems which the physicist and biologist alike attempt to solve. The two classes of problems differ principally in the fact that the conditions of the world of life are so incomparably more intricate than those of the world of matter that the biologist is compelled to abandon the attempt to determine the absolute amount of the influence of the various causes which have affected the existence of species. His conclusions are merely qualitative and general, and he is almost universally compelled to refrain from asserting even in general terms what are the reasons which have rendered one form of animal life stable and persistent, and another unstable and evanescent.

On the other hand, the physicist, as a general rule, does not rest satisfied unless he obtains a quantitative estimate of various causes and effects on the systems of matter which he discusses. Yet there are some problems of physical evolution in which the conditions are so complex that the physicist is driven, as is the biologist, to rest satisfied with qualitative rather than quantitative conclusions. But he is not content with such crude conclusions except in the last resort, and he generally prefers to proceed by a different method.

The mathematician mentally constructs

an ideal mechanical system or model, which is intended to represent in its leading features the system he wants to examine. It is often a task of the utmost difficulty to devise such a model, and the investigator may perchance unconsciously drop out as unimportant something which is really essential to represent actuality. He next examines the conditions of his ideal system, and determines, if he can, all the possible stable and unstable configurations, together with the circumstances which will cause transitions from one to the other. Even when the working model has been successfully imagined, this latter task may often overtax the powers of the mathematician. Finally it remains for him to apply his results to actual matter, and to form a judgment of the extent to which it is justifiable to interpret nature by means of his results.

The remainder of my address will be occupied by an account of various investigations which will illustrate the principles and methods which I have now explained in general terms.

The fascinating idea that matter of all kinds has a common substratum is of remote antiquity. In the middle ages the alchemists, inspired by this idea, conceived the possibility of transforming the baser metals into gold. The sole difficulty seemed to them the discovery of an appropriate series of chemical operations. We now know that they were always indefinitely far from the goal of their search, yet we must accord to them the honor of having been the pioneers of modern chemistry.

The object of alchemy, as stated in modern language, was to break up or dissociate the atoms of one chemical element into its component parts, and afterwards to reunite them into atoms of gold. Although even the dissociative stage of the alchemistic problem still lies far beyond the power of the chemist, yet modern researches seem to furnish a sufficiently clear idea of the structure of atoms to enable us to see what would have to be done to effect a transformation of elements. Indeed, in the complex changes which are found to occur spontaneously in uranium, radium and the allied metals we are probably watching a spontaneous dissociation and transmutation of elements.

Nature selection may seem, at first sight, as remote as the poles asunder from the ideas of the alchemist, yet dissociation and transmutation depend on the instability and regained stability of the atom, and the survival of the stable atom depends on the principle of natural selection.

Until some ten years ago the essential diversity of the chemical elements was accepted by the chemist as an ultimate fact, and indeed the very name of atom, or that which can not be cut, was given to what was supposed to be the final indivisible portion of matter. The chemist thus proceeded in much the same way as the biologist who, in discussing evolution, accepts the species as his working unit. Accordingly, until recently the chemist discussed working models of matter of atomic structure, and the vast edifice of modern chemistry has been built with atomic bricks.

But within the last few years the electrical researches of Lenard, Röntgen, Becquerel, the Curies, of my colleagues Larmor and Thomson, and of a host of others, have shown that the atom is not indivisible, and a flood of light has been thrown thereby on the ultimate constitution of matter. Amongst all these fertile investigators it seems to me that Thomson stands preeminent, because it is principally through him that we are to-day in a better position for picturing the structure of an atom than was ever the case before.

Even if I had the knowledge requisite for a complete exposition of these investigations, the limits of time would compel me to confine myself to those parts of the subject which bear on the constitution and origin of the elements.

It has been shown, then, that the atom, previously supposed to be indivisible, really consists of a large number of component parts. By various convergent lines of experiment it has been proved that the simplest of all atoms—namely, that of hydrogen—consists of about 800 separate parts; while the number of parts in the atom of the denser metals must be counted by tens of thousands. These separate parts of the atom have been called corpuscles or electrons, and may be described as particles of negative electricity. It is paradoxical, yet true, that the physicist knows more about these ultra-atomic corpuscles and can more easily count them than is the case with the atoms of which they form the parts.

The corpuscles, being negatively electrified, repel one another just as the hairs on a person's head mutually repel one another when combed with a vulcanite comb. The mechanism is as yet obscure whereby the mutual repulsion of the negative corpuscles is restrained from breaking up the atom, but a positive electrical charge, or something equivalent thereto, must exist in the atom, so as to prevent disruption. The existence in the atom of this community of negative corpuscles is certain, and we know further that they are moving with speeds which may in some cases be comparable to the volocity of light, namely, 200,000 miles a second. But the mechanism whereby they are held together in a group is hypothetical.

It is only just a year ago that Thomson suggested, as representing the atom, a mechanical or electrical model whose properties could be accurately examined by mathematical methods. He would be the first to admit that his model is at most merely a crude representation of actuality, yet he has been able to show that such an atom must possess mechanical and electrical properties which simulate, with what Whetham describes as 'almost Satanic exactness,' some of the most obscure and yet most fundamental properties of the chemical elements. 'Se non è vero, è ben trovato,' and we are surely justified in believing that we have the clue which the alchemists sought in vain.

Thomson's atom consists of a globe charged with positive electricity, inside which there are some thousand or thousands of corpuscles of negative electricity, revolving in regular orbits with great velocities. Since two electrical charges repel one another if they are of the same kind, and attract one another if they are of opposite kinds, the corpuscles mutually repel one another, but all are attracted by the globe containing them. The forces called into play by these electrical interactions are clearly very complicated, and you will not be surprised to learn that Thomson found himself compelled to limit his detailed examination of the model atom to one containing about seventy corpuscles. It is indeed a triumph of mathematical power to have determined the mechanical conditions of such a miniature planetary system as I have described.

It appears that there are definite arrangements of the orbits in which the corpuscles must revolve, if they are to be persistent or stable in their motions. For the purpose of general discussion, which is all that I shall attempt, you may take it that the number of corpuscles in such a community is fixed; and we may state that definite numbers of corpuscles are capable

of association in stable communities of definite types.

An infinite number of communities are possible, possessing greater or lesser degrees of stability. Thus the corpuscles in one such community might make thousands of revolutions in their orbits before instability declared itself; such an atom might perhaps last for a long time as estimated in millionths of seconds, but it must finally break up and the corpuscles must disperse or rearrange themselves after the ejection of some of their number. We are thus led to conjecture that the several chemical elements represent those different kinds of communities of corpuscles which have proved by their stability to be successful in the struggle for life. If this is so, it is almost impossible to believe that the successful species have existed for all time, and we must hold that they originated under conditions about which I must forbear to follow Sir Norman Lockyer in speculating.

But if the elements were not eternal in the past, we must ask whether there is reason to believe that they will be eternal in the future. Now, although the conception of the decay of an element and its spontaneous transmutation into another element would have seemed absolutely repugnant to the chemist until recently, yet analogy with other moving systems seems to suggest that the elements are not eternal.

At any rate it is of interest to pursue to its end the history of the model atom which has proved to be so successful in imitating the properties of matter. The laws which govern electricity in motion indicate that such an atom must be radiating or losing energy, and therefore a time must come when it will run down, as a clock does. When this time comes it will spontaneously transmute itself into an element which needs less energy than was required in the former state. Thomson conceives that an atom might be constructed after his model so that its decay should be very slow. It might, he thinks, be made to run for a million years, but it would not be eternal.

Such a conclusion is an absolute contradiction to all that was known of the elements until recently, for no symptoms of decay are perceived, and the elements existing in the solar system must already have lasted for millions of years. Nevertheless, there is good reason to believe that in radium, and in other elements possessing very complex atoms, we do actually observe that break-up and spontaneous rearrangement which constitute a transmutation of elements.

It is impossible as yet to say how science will solve this difficulty, but future discovery in this field must surely prove deeply interesting. It may well be that the train of thought which I have sketched will ultimately profoundly affect the material side of human life, however remote it may now seem from our experiences of daily life.

I have not as yet made any attempt to represent the excessive minuteness of the corpuscles, of whose existence we are now so confident; but, as an introduction to what I have to speak of next, it is necessary to do so. To obtain any adequate conception of their size we must betake ourselves to a scheme of threefold magnification. Lord Kelvin has shown that if a drop of water were magnified to the size of the earth the molecules of water would be of a size intermediate between that of a cricket-ball and of a marble. Now each molecule contains three atoms, two being of hydrogen and one of oxygen. The molecular system probably presents some sort of analogy with that of a triple star; the three atoms, replacing the stars, revolving about one another in some sort of dance which can not be exactly described. I doubt

whether it is possible to say how large a part of the space occupied by the whole molecule is occupied by the atoms; but perhaps the atoms bear to the molecule some such relationship as the molecule to the drop of water referred to. Finally, the corpuscles may stand to the atom in a similar scale of magnitude. Accordingly, a threefold magnification would be needed to bring these ultimate parts of the atom within the range of our ordinary scales of measurement.

I have already considered what would be observed under the triply powerful microscope, and must now return to the intermediate stage of magnification, in which we consider those communities of atoms which form molecules. This is the field of research of the chemist. Although prudence would tell me that it would be wiser not to speak of a subject of which I know so little, yet I can not refrain from saying a few words.

The community of atoms in water has been compared with a triple star, but there are others known to the chemist in which the atoms are to be counted by fifties and hundreds, so that they resemble constellations.

I conceive that here again we meet with conditions similar to those which we have supposed to exist in the atom. Communities of atoms are called chemical combinations, and we know that they possess every degree of stability. The existence of some is so precarious that the chemist in his laboratory can barely retain them for a moment; others are so stubborn that he can barely break them up. In this case dissociation and reunion into new forms of communities are in incessant and spontaneous progress throughout the world. The more persistent or more stable combinations succeed in their struggle for life, and are found in vast quantities, as in the cases of common salt and of the combinations of silicon. But no one has ever found a mine of guncotton, because it has so slight a power of resistance. If, through some accidental collocation of elements, a single molecule of guncotton were formed, it would have but a short life.

Stability is, further, a property of relationship to surrounding conditions; it denotes adaptation to environment. Thus salt is adapted to the struggle for existence on the earth, but it can not withstand the severer conditions which exist in the sun.

G. H. Darwin.

University of Cambridge.

[The president here announced that he proposed to consider various theories of evolution in the heavens in the second portion of his address, to be delivered at Johannesburg on Wednesday, August 30.]

ADDRESS TO THE MATHEMATICAL AND PHYSICAL SECTION OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.[1]

According to an established and unchallenged custom, our proceedings are inaugurated by an address from the president. Let me begin it by discharging a duty which, unhappily, is of regular recurrence. If your president only mentions names when he records the personal losses suffered during the year by the sciences of the section, the corporate sense of the section will be able to appreciate the losses with a deeper reality than can be conveyed by mere words.

In Mr. Ronald Hudson, who was one of our secretaries at the Cambridge meeting a year ago, we have lost a mathematician whose youthful promise had ripened into early performance. The original work which he had accomplished is sufficient, both in quality and in amount, to show that much has been given, and that much more

[1] South Africa, 1905.

could have been expected. His alert and bright personality suggested that many happy years lay before him. All these fair hopes were shattered in a moment by an accident upon a Welsh hillside; and his friends, who were many, deplore his too early death at the age of twenty-eight.

The death of Mr. Frank McClean has robbed astronomy of one of its most patient workers and actively creative investigators. I wish that my own knowledge could enable me to give some not inadequate exposition of his services to the science which he loved so well. He was a man of great generosity which was wise, discriminating and more than modest; to wide interests in science he united wide interests in the fine arts. Your astronomer royal, in the Royal Observatory at Cape Town, will not lightly forget his gift of a great telescope: and the University of Cambridge, the grateful recipient of his munificent endowment of the Isaac Newton studentships fifteen years ago, and of his no less munificent bequest of manuscripts, early printed books, and objects of art, has done what she can towards perpetuating his memory for future generations by including his name in the list, that is annually recited in solemn service, of her benefactors who have departed this life.

In the early days of our gatherings, when the set of cognate sciences with which we specially are concerned had not yet diverged so widely from one another alike in subject and in method, this inaugurating address was characterized by a brevity that a president can envy and by a freedom from formality that even the least tolerant audience could find admirable. The lapse of time, perhaps assisted by presidential ambitions which have been veiled under an almost periodic apology for personal shortcomings, has deprived these addresses of their ancient brevity, and has invested them with an air of oracular gravity. The topics vary from year to year, but this variation is due to the predilection of the individual presidents; the types of address are but few in number. Sometimes, indeed, we have had addresses that can not be ranged under any comprehensive type. Thus one year we had an account of a particular school of long-sustained consecutive research; another year the president made a constructive (and perhaps defiant) defence of the merits of a group of subjects that were of special interest to himself. But there is one type of address which recurs with iterated frequency; it is constituted by a general account of recent progress in discovery, or by a survey of modern advances in some one or other of the branches of science to which the multiple activities of our section are devoted. No modern president has attempted a general survey of recent progress in all the branches of our group of sciences; such an attempt will probably be deferred until the council discovers a president who, endowed with the omniscience of a Whewell, and graced with the tongue of men and of angels, shall once again unify our discussions.

On the basis of this practise, it would have been not unreasonable on my part to have selected some topic from the vast range of pure mathematics, and to have expounded some body of recent investigations. There certainly is no lack of topics; our own day is peculiarly active in many directions. Thus, even if we leave on one side the general progress that has been made in many of the large branches of mathematics during recent years, it is easy to hint at numerous subjects which could occupy the address of a mathematical president. He might, for instance, devote his attention to modern views of continuity, whether of quantity or of space; he might be heterodox or orthodox as to the so-called laws of motion; he might expound his

notions as to the nature and properties of analytic functionality; a discussion of the hypotheses upon which a consistent system of geometry can be framed could be made as monumental as his ambition might choose; he could revel in an account of the most recent philosophical analysis of the foundations of mathematics, even of logic itself, in which all axioms must either be proved or be compounded of notions that defy resolution by the human intellect at the present day. Such discussions are bound to be excessively technical unless they are expressed in unmathematical phraseology; when they are so expressed, and in so far as such expression is possible, they become very long and they can be very thin. Moreover, had I chosen any topic of this character, it would have been the merest natural justice to have given early utterance of the sibyllic warning to the uninitiated; I must also have bidden the initiated that, as they come, they should summon all the courage of their souls. So I abstain from making such an experiment upon an unwarned audience; yet it is with reluctance that I have avoided subjects in the range which to me is of peculiar interest.

On the other hand, I must ask your indulgence for not conforming to average practice and expectation. My desire is to mark the present occasion by an address of unspecialized type which, while it is bound to be mainly mathematical in tenor, and while it will contain no new information, may do little more than recall some facts that are known, and will comment briefly upon obvious tendencies. Let me beg you to believe that it is no straining after novelty which has dictated my choice; such an ambition has a hateful facility of being fatal both to the performer and to the purpose. It is the strangeness of our circumstances, in both place and time, that has suggested my subject. With an adventurous audacity that quite overcrows the spirit of any of its past enterprises, the British Association for the Advancement of Science has traveled south of the Equator and, in accepting your hospitality, proposes to traverse much of South Africa. The prophet of old declared that 'many shall run to and fro, and knowledge shall be increased'; if the second part of the prophecy is not fulfilled, it will not be for the want of our efforts to fulfill the first part. And if the place and the range of this peripatetic demonstration of our annual corporate activity are unusual, the occasion chosen for this enterprise recalls memories that are fundamental in relation to our subject. It is a modern fashion to observe centenaries. In this section we are in the unusual position of being able to observe three scientific centenaries in one and the same year. Accordingly I propose to refer to these in turn, and to indicate a few of the events filling the intervals between them; but my outline can be of only the most summary character, for the scientific history is a history of three hundred years, and, if searching enough, it could include the tale of nearly all mathematical and astronomical and physical science.

It is exactly three hundred years since Bacon published 'The Advancement of Learning.' His discourse, alike in matter, in thought, in outlook, was in advance of its time, and it exercised no great influence for the years that immediately followed its appearance; yet that appearance is one of the chief events in the origins of modern natural science. Taking all knowledge to be his province, he surveys the whole of learning: he deals with the discredits that then could attach to it; he expounds both the dignity and the influence of its pursuit; and he analyzes all learning, whether of things divine or of things human, into

its ordered branches. He points out deficiencies and gaps; not a few of his recommendations of studies, at his day remaining untouched, have since become great branches of human thought and human inquiry. But what concerns us most here is his attitude towards natural philosophy, all the more remarkable because of the state of knowledge of that subject in his day, particularly in England. It is true that Gilbert had published his discovery of terrestrial magnetism some five years earlier, a discovery followed only too soon by his death; but that was the single considerable English achievement in modern science down to Bacon's day.

In order to estimate the significance of Bacon's range of thought let me recite a few facts, as an indication of the extreme tenuity of progressive science in that year (1605). They belong to subsequent years, and may serve to show how restricted were the attainments of the period, and how limited were the means of advance. The telescope and the microscope had not yet been invented. The simple laws of planetary motion were not formulated, for Kepler had them only in the making. Logarithms were yet to be discovered by Napier, and to be calculated by Briggs. Descartes was a boy of nine and Fermat a boy of only four, so that analytical geometry, the middle-life discovery of both of them, was not yet even a dream for either of them. The Italian mathematicians, of whom Cavalieri is the least forgotten, were developing Greek methods of quadrature by a transformed principle of indivisibles; but the infinitesimal calculus was not really in sight, for Newton and Leibnitz were yet unborn. Years were to elapse before, by the ecclesiastical tyranny over thought, Galileo was forced to make a verbal disavowal of his adhesion to the Copernican system of astronomy, of which he was still to be the protagonist in propounding any reasoned proof. Some mathematics could be had, cumbrous arithmetic and algebra, some geometry lumbering after Euclid, and a little trigonometry; but these were mainly the mathematics of the Renaissance, no very great advance upon the translated work of the Greeks and the transmitted work of the Arabs. Even our old friend the binomial theorem, which now is supposed to be the possession of nearly every able schoolboy, remained unknown to professional mathematicians for more than half a century yet to come.

Nor is it merely on the negative side that the times seemed unpropitious for a new departure; the spirit of the age in the positive activities of thought and deed was not more sympathetic. Those were the days when the applications of astronomy had become astrology. Men sought for the elixir of life and pondered over the transmutation of baser metals into gold. Shakespeare not long before had produced his play 'As You Like It,' where the strange natural history of the toad which,

> Ugly and venomous,
> Bears yet a precious jewel in his head,

is made a metaphor to illustrate the sweetening uses of adversity. The stiffened Elizabethan laws against witchcraft were to be sternly administered for many a year to come. It was an age that was pulsating with life and illuminated by fancy, but the life was the life of strong action and the fancy was the fancy of ideal imagination; men did not lend themselves to sustained and abstract thought concerning the nature of the universe. When we contemplate the spirit that such a state of knowledge might foster towards scientific learning, and when we recall the world into which Bacon's treatise was launched, we can well be surprised at his far-reaching views, and we can marvel at his isolated wisdom.

Let me select a few specimens of his judgments, chosen solely in relation to our own subjects. When he says

> All true and fruitful natural philosophy hath a double scale or ladder, ascendent and descendent, ascending from experiments to the invention of causes, and descending from causes to the invention of new experiments; therefore I judge it most requisite that these two parts be severally considered and handled—

he is merely expounding, in what now is rather archaic phrase, the principles of the most ambitious investigations in the natural philosophy of subsequent centuries. When he speaks of

> the operation of the relative and adventive characters of essences, as quantity, similitude, diversity, possibility and the rest; with this distinction and provision, that they be handled as they have efficacy in nature, and not logically—

I seem to hear the voice of the applied mathematician warning the pure mathematician off the field. When, after having divided natural philosophy into physic and metaphysic (using these words in particular meanings, and including mathematics in the second of the divisions), he declares

> physics should contemplate that which is inherent in matter, and therefore transitory, and metaphysics that which is abstracted and fixed; * * * physic describeth the causes of things, but the variable or respective causes; and metaphysic the fixed and constant causes—

there comes before my mind the army of physicists of the present day, who devote themselves unwearyingly to the properties of matter and willingly cast aside elaborate arguments and calculations. When he argues that

> many parts of nature can neither be invented with sufficient subtilty, nor demonstrated with sufficient perspicuity, nor accommodated unto use with sufficient dexterity, without the aid and intervening of the mathematics—

he might be describing the activity of subsequent generations of philosophers, astronomers and engineers. And in the last place (for my extracts must have some end), when he expresses the opinion

> that men do not sufficiently understand the excellent use of the pure mathematics, in that they do remedy and cure many defects in the wit and faculties intellectual. For if the wit be too dull, they sharpen it; if too wandering, they fix it; if too inherent in the sense, they abstract it; * * * in the mathematics, that which is collateral and intervenient is no less worthy than that which is principal and intended—

I seem to hear an advocate for the inclusion of elementary mathematics in any scheme of general education. At the same time, I wonder what Bacon, who held such an exalted estimate of pure mathematics in its gray dawn, would have said by way of ampler praise of the subject in its fuller day.

It was a splendid vision of inductive science as of other parts of learning: it contained a revelation of the course of progress through the centuries to come. Yet the facts of to-day are vaster than the vision of that long-ago yesterday, and human activity has far outstripped the dreams of Bacon's opulent imagination. He was the harbinger (premature in many respects it must be confessed, but still the harbinger) of a new era. At a time when we are making a new departure in the fulfilment of the purpose of our charter, which requires us 'to promote the intercourse of those who cultivate science in different parts of the British Empire, our Association for the Advancement of Science may pause for a moment to gaze upon the vision revealed three centuries ago in the 'Advancement of Learning' by a philosopher whose influence upon the thought of the world is one of the glories of our nation.

I have implied that Bacon's discourse was in advance of its age, so far as England was concerned. Individuals could make their mark in isolated fashion. Thus Harvey, in his hospital work in London, discovered the circulation of the blood; Na-

pier, away on his Scottish estates, invented logarithms; and Horrocks, in the seclusion of a Lancashire curacy, was the first to observe a transit of Venus. But for more than half a century the growth of physical science was mainly due to workers on the continent of Europe. Galileo was making discoveries in the mechanics of solids and fluids, and, specially, he was building on a firm foundation the fabric of the system of astronomy, hazarded nearly a century before by Copernicus; he still was to furnish, by bitter experience, one of the most striking examples in the history of the world that truth is stronger than dogma. Kepler was gradually elucidating the laws of planetary motion, of which such significant use was made later by Newton; and Descartes, by his creation of analytical geometry, was yet to effect such a constructive revolution in mathematics that he might not unfairly be called the founder of modern mathematics. In England the times were out of scientific joint: the political distractions of the Stuart troubles, and the narrow theological bitterness of the commonwealth, made a poor atmosphere for the progress of scientific learning, which was confined almost to a faithful few. The fidelity of those few, however, had its reward; it was owing to their steady confidence and to their initiative that the Royal Society of London was founded in 1662 by Charles II. At that epoch, science (to quote the words of a picturesque historian) became the fashion of the day. Great Britain began to contribute at least her fitting share to the growing knowledge of nature; and her scientific activity in the closing part of the seventeenth century was a realization, wonderful and practical, of a part of Bacon's dream. Undoubtedly the most striking contribution made in that period is Newton's theory of gravitation, as expounded in his 'Principia,' published in 1687.

That century also saw the discovery of the fluxional calculus by Newton, and of the differential calculus by Leibnitz. These discoveries provided the material for one of the longest and most deadening controversies as to priority in all the long history of those tediously barren occupations; unfortunately they are dear to minds which cannot understand that a discovery should be used, developed, amplified, but should not be a cause of envy, quarrel, or controversy. Let me say, incidentally, that the controversy had a malign influence upon the study of mathematics as pursued in England.

Also, the undulatory theory of light found its first systematic, if incomplete, exposition in the work of Huygens before the century was out. But Newton had an emission theory of his own, and so the undulatory theory of Huygens found no favor in England until rather more than a hundred years later; the researches of Thomas Young established it on a firm foundation.

Having thus noted some part of the stir in scientific life which marked the late years of the seventeenth century, let me pass to the second of our centenaries: it belongs to the name of Edmond Halley. Quite independently of his achievement connected with the year 1705 to which I am about to refer, there are special reasons for honoring Halley's name in this section at our meeting in South Africa. When a young man of twenty-one he left England for St. Helena, and there, in the years 1676–1678, he laid the foundations of stellar astronomy for the southern hemisphere; moreover, in the course of his work he there succeeded in securing the first complete observation of a transit of Mercury. After his return to England, the next few years of his life were spent in laying science under a special debt that can hardly be over-appreciated. He placed himself in personal relation with Newton, propounded to him questions and

offered information; and it is now a commonplace statement that Halley's questions and suggestions caused Newton to write the 'Principia.' More than this, we know that Newton's great treatise saw the light only through Halley's persuasive insistence, through his unwearying diligence in saving Newton all cares and trouble and even pecuniary expense, and through his absolutely self-sacrificing devotion to what he made an unwavering duty at that epoch in his life. Again, he appears to have been the first organizer of a scientific expedition, as distinct from a journey of discovery, towards the southern seas: he sailed as far as the fifty-second degree of southern latitude, devised the principle of the sextant in the course of his voyaging, and, as a result of the voyage, he produced a general chart of the Atlantic Ocean, with special reference to the deviation of the compass. Original, touched with genius, cheery of soul, strenuous in thought and generous by nature, he spent his life in a continuously productive devotion to astronomical science, from boyhood to a span of years far beyond that which satisfied the psalmist's broodings. I have selected a characteristic incident in his scientific activity, one of the most brilliant (though it can not be claimed as the most important) of his astronomical achievements; it strikes me as one of the most chivalrously bold acts of convinced science within my knowledge. It is only the story of a comet.

I have just explained, very briefly, Halley's share in the production of Newton's 'Principia'; his close concern with it made him the Mahomet of the new dispensation of the astronomical universe, and he was prepared to view all its phenomena in the light of that dispensation. A comet had appeared in 1682—it was still the age when scientific men could think that, by a collision between the earth and a comet, 'this most beautiful order of things would be entirely destroyed and reduced to its ancient chaos'; but this fear was taken as a 'by-the-bye,' which happily interfered with neither observations nor calculations. Observations had duly been made. The data were used to obtain the elements of the orbit, employing Newton's theory as a working hypothesis; and he expresses an incidental regret as to the intrinsic errors of assumed numerical elements and of recorded observations. It then occurred to Halley to calculate similarly the elements of the comet which Kepler and others had seen in 1607, and of which records had been made; the Newtonian theory gave elements in close accord with those belonging to the comet calculated from the latest observations, though a new regret is expressed that the 1607 observations had not been made with more accuracy. On these results he committed himself (being then a man of forty-nine years of age) to a prophecy (which could not be checked for fifty-three years to come) that the comet would return about the end of the year 1758 or the beginning of the next succeeding year; he was willing to leave his conclusion 'to be discussed by the care of posterity, after the truth is found out by the event.' But not completely content with this stage of his work, he obtained with difficulty a book by Apian, giving an account of a comet seen in 1531 and recording a number of observations. Halley, constant to his faith in the Newtonian hypothesis, used that hypothesis to calculate the elements of the orbit of the Apian comet; once more regretting the uncertainty of the data and discounting a very grievous error committed by Apian himself, Halley concluded that the Apian comet of 1531, and the Kepler comet of 1607, and the observed comet of 1682 were one and the same. He confirmed his prediction as to the date of its return, and he

concludes his argument with a blend of confidence and patriotism:—

> Wherefore if according to what we have already said it should return again about the year 1758, candid posterity will not refuse to acknowledge that this was first discovered by an *Englishman*.

Such was Halley's prediction published in the year 1705. The comet pursued its course, and it was next seen on Christmas Day, 1758. Candid posterity, so far from refusing to acknowledge that the discovery was made by an Englishman, has linked Halley's name with the comet, possibly for all time.

We all now could make announcements on the subject of Halley's comet; their fulfilment could be awaited serenely. No vision or inspiration is needed; calculations and corrections will suffice. The comet was seen in 1835, and it is expected again in 1910. No doubt our astronomers will be ready for it; and the added knowledge of electrical science, in connection particularly with the properties of matter, may enable them to review Bessel's often-discussed conjecture as to an explanation of the emission of a sunward tail. But Halley's announcement was made during what may be called the immaturity of the gravitation theory; the realization of the prediction did much to strengthen the belief in the theory and to spread its general acceptance; the crown of conviction was attained with the work of Adams and Leverrier in the discovery, propounded by theory and verified by observation, of the planet Neptune. I do not known an apter illustration of Bacon's dictum that has already been quoted, 'All true and fruitful natural philosophy hath a double scale, ascending from experiments to the invention of causes, and descending from causes to the invention of new experiments.' The double process, when it can be carried out, is one of the most effective agents for the increase of trustworthy knowledge. But until the event justified Halley's prediction, the Cartesian vortex-theory of the universe was not completely replaced by the Newtonian theory; the Cartesian votaries were not at once prepared to obey Halley's jubilant, if stern, injunction to 'leave off trifling * * * with their vortices and their absolute plenum * * * and give themselves up to the study of truth.'

The century that followed the publication of Halley's prediction shows a world that is steadily engaged in the development of the inductive sciences and their applications. Observational astronomy continued its activity quite steadily, reinforced towards the end of the century by the first of the Herschels. The science of mathematical (or theoretical) astronomy was created in a form that is used to this day; but before this creation could be effected there had to be a development of mathematics suitable for the purpose. The beginnings were made by the Bernoullis (a family that must be of supreme interest to Dr. Francis Galton in his latest statistical compilations, for it contained no fewer than seven mathematicians of mark, distributed over three generations), but the main achievements are due to Euler, Lagrange and Laplace. In particular, the infinitesimal calculus in its various branches (including, that is to say, what we call the differential calculus, the integral calculus, and differential equations) received the development that now is familiar to all who have occasion to work in the subject. When this calculus was developed, it was applied to a variety of subjects; the applications, indeed, not merely influenced, but immediately directed, the development of the mathematics. To this period is due the construction of analytical mechanics at the hands of Euler, d'Alembert, Lagrange and Poisson; but the most significant achieve-

ment in this range of thought is the mathematical development of the Newtonian theory of gravitation applied to the whole universe. It was made, in the main, by Lagrange, as regards the wider theory, and by Laplace, as regards the amplitude of detailed application. But it was a century that also saw the obliteration of the ancient doctrines of caloric and phlogiston, through the discoveries of Rumford and Davy of the nature and relations of heat. The modern science of vibrations had its beginnings in the experiments of Chladni, and, as has already been stated, the undulatory theory of light was rehabilitated by the researches of Thomas Young. Strange views as to the physical constitution of the universe then were sent to the limbo of forgotten ignorance by the early discoveries of modern chemistry; and engineering assumed a systematic and scientific activity, the limits of which seem bounded only by the cumulative ingenuity of successive generations. But in thus attempting to summarize the progress of science in that period, I appear to be trespassing upon the domains of other sections; my steps had better be retraced so as to let us return to our own upper air. If I mention one more fact (and it will be a small one), it is because of its special connection with the work of this section. As you are aware, the elements of Euclid have long been the standard treatise of elementary geometry in Great Britain; and the Greek methods, in Robert Simson's edition, have been imposed upon candidates in examination after examination. But Euclid is on the verge of being disestablished; my own University of Cambridge, which has had its full share in maintaining the restriction to Euclid's methods, and which was not uninfluenced by the report of a committee of this association upon the subject, will, some six or seven weeks hence, hold its last examination in which those methods are prescriptively required. The disestablishment of Euclid from tyranny over the youthful student on the continent of Europe was effected before the end of the eighteenth century.

But it is time for me to pass on to the third of the centenaries, with which the present year can be associated. Not so fundamental for the initiation of modern science as was the year in which the 'Advancement of Learning' was published, not so romantic in the progress of modern science as was the year in which Halley gave his prediction to the world, the year 1805 (turbulent as it was with the strife of European politics) is marked by the silent voices of a couple of scientific records. In that year Laplace published the last progressive instalment of his great treatise on 'Celestial Mechanics,' the portion that still remained for the future being solely of an historical character; the great number of astronomical phenomena which he had been able to explain by his mathematical presentation of the consequences of the Newtonian theory would, by themselves, have been sufficient to give confidence in the validity of that theory. In that year also Monge published his treatise, classical and still to be read by all students of the subject, 'The Application of Algebra to Geometry'; it is the starting point of modern synthetic geometry, which has marched in ample development since his day. These are but landmarks in the history of mathematical science, one of them indicating the completed attainment of a tremendous task, the other of them initiating a new departure; both of them have their significance in the progress of their respective sciences.

When we contemplate the activity and the achievements of the century that has elapsed since the stages which have just been mentioned were attained in mathematical science, the amount, the variety, the

progressive diligence, are little less than bewildering. It is not merely the vast development of all the sciences that calls for remark: no less striking is their detailed development. Each branch of science now has an enormous array of workers, a development rendered more easily possible by the growing increase in the number of professional posts; and through the influence of these workers and their labors there is an ever-increasing body of scientific facts. Yet an aggregate of facts is not an explanatory theory any more necessarily than a pile of carefully fashioned stones is a cathedral; and the genius of a Kepler and a Newton is just as absolutely needed to evolve the comprehending theory as the genius of great architects was needed for the Gothic cathedrals of France and of England. Not infrequently it is difficult to make out what is the main line of progress in any one subject, let alone in a group of subjects; and though illumination comes from striking results that appeal, not merely to the professional workers, but also to unprofessional observers, this illumination is the exception rather than the rule. We can allow, and we should continue to allow, freedom of initiative in all directions. That freedom sometimes means isolation, and its undue exercise can lead to narrowness of view. In spite of the complex ramification of the sciences which it has fostered, it is a safer and a wiser spirit than that of uncongenial compulsion, which can be as dogmatic in matters scientific as it can be in matters theological. Owing to the varieties of mind, whether in individuals or in races, the progress of thought and the growth of knowledge are not ultimately governed by the wishes of any individual or the prejudices of any section of individuals. Here, a school of growing thought may be ignored; there, it may be denounced as of no importance; somewhere else, it may be politely persecuted out of possible existence. But the here, and the there, and the somewhere else do not make up the universe of human activity; and that school, like Galileo's earth in defiance of all dogmatic authority, still will move.

This complete freedom in the development of scientific thought, when the thought is applied to natural phenomena, is all the more necessary because of the ways of nature. Physical nature cares nothing for theories, nothing for calculations, nothing for difficulties, whatever their source; she will only give facts in answer to our questions, without reasons and without explanations; we may explain as we please and evolve laws as we like, without her help or her hindrance. If from our explanations and our laws we proceed to prediction, and if the event justifies the prediction through agreement with recorded fact, well and good: so far we have a working hypothesis. The significance of working hypotheses, in respect of their validity and their relation to causes, is a well-known battle-ground of dispute between different schools of philosophers; it need not detain us here and now. On the other hand, when we proceed from our explanations and our laws to a prediction, and the prediction in the end does not agree with the fact to be recorded, it is the prediction that has to give way. But the old facts remain and the new fact is added to them; and so facts grow until some working law can be extracted from them. This accumulation of facts is only one process in the solution of the universe: when the compelling genius is not at hand to transform knowledge into wisdom, useful work can still be done upon them by the construction of organized accounts which shall give a systematic exposition of the results, and shall place them as far as may be in relative significance.

Let me pass from these generalities, which have been suggested to my mind by the consideration of some of the scientific changes that have taken place during the last hundred years, and let me refer briefly to some of the changes and advances which appear to me to be most characteristic of that period. It is not that I am concerned with a selection of the most important researches of the period. Estimates of relative importance are often little more than half-concealed expressions of individual preferences or personal enthusiasms; and though each enthusiastic worker, if quite frank in expressing his opinion, would declare his own subject to be of supreme importance, he would agree to a compromise that the divergence between the different subjects is now so wide as to have destroyed any common measure of comparison. My concern is rather with changes, and with tendencies where these can be discerned.

The growth of astronomy has already occupied so large a share of my remarks that few more words can be spared here. Not less, but more, remarkable than the preceding centuries in the actual exploration of the heavens, which has been facilitated so much by the improvements in instruments and is reinforced to such effect by the cooperation of an ever-growing band of American astronomers, it has seen a new astronomy occupy regions undreamt of in the older days. New methods have supplemented the old; spectroscopy has developed a science of physics within astronomy; and the unastronomical brain reels at the contents of the photographic chart of the heavens which is now being constructed by international cooperation and will, when completed, attempt to map ten million stars (more or less) for the human eye.

Nor has the progress of physics, alike on the mathematical side and the experimental side, been less remarkable or more restricted than that of astronomy. The elaborate and occasionally fantastic theories of the eighteenth century, in such subjects as light, heat, even as to matter itself, were rejected in favor of simpler and more comprehensive theories. There was one stage when it seemed as if the mathematical physicists were gradually overtaking the experimental physicists; but the discoveries in electricity begun by Faraday left the mathematicians far behind. Much has been done towards the old duty, ever insistent, of explaining new phenomena; and the names of Maxwell, Weber, Neumann, and Hertz need only to be mentioned in order to suggest the progress that has been made in one subject alone. We need not hesitate to let our thoughts couple, with the great physicists of the century, the leaders of that brilliant band of workers upon the properties of matter who carry us on from wonder to wonder with the passage of each successive year.

Further, it has been an age when technical applications have marched at a marvelous pace. So great has been their growth that we are apt to forget their comparative youth; yet it was only the middle of the century which saw the awakening from what now might be regarded as the dark ages. Nor is the field of possible application nearing exhaustion: on the contrary, it seems to be increasing by reason of new discoveries in pure science that yet will find some beneficent outcome in practice. Invisible rays and wireless telegraphy may be cited as instances that are occupying present activities, not to speak of radium, the unfolding of whose future is watched by eager minds.

One gap, indeed, in this subject strikes me. There are great histories of mathematics and great histories of astronomy; I can find no history of physics on the grand scale. Some serviceable manuals there are,

as well as monographs on particular topics; what seems to me to be lacking is some comprehensive and comparative survey of the whole range. The history of any of the natural sciences, like the history of human activity, is not merely an encyclopædic record of past facts; it reveals both the spirit and the wealth which the past has bequeathed to the present, and which, in due course, the present will influence before transmission to the future. Perhaps all our physicists are too busy to spare the labor needed for the production of a comprehensive history; yet I cannot help thinking that such a contribution to the subject would be of great value, not to physicists alone.

But, as you hear me thus referring to astronomy and to physics, some of you may think of the old Roman proverb which made the cobbler not to look above his last; so I take the opportunity of referring very briefly to my own subject. One of the features of the century has been the continued development of mathematics. As a means of calculation the subject was developed as widely during the earlier portion of the century as during the preceding century; it soon began to show signs of emergence as an independent science, and the later part of the century has witnessed the emancipation of pure mathematics. It was pointed out, in connection with the growth of theoretical astronomy, that mathematics developed in the direction of its application to that subject. When the wonderful school of French physicists, composed of Monge, Carnot, Fourier, Poisson, Poinsot, Ampère and Fresnel (to mention only some names), together with Gauss, Kirchhoff and von Helmholtz in Germany, and Ivory, Green, Stokes, Maxwell and others in England, applied their mathematics to various branches of physics, for the most part its development was that of an ancillary subject. The result is the superb body of knowledge that may be summarized under the title of 'mathematical physics'; but the final interest is the interest of physics, though the construction has been the service of mathematics. Moreover, this tendency was deliberate, and was avowed in no uncertain tone. Thus Fourier could praise the utility of mathematics by declaring that 'there was no language more universal or simpler, more free from errors or obscurity, more worthy of expressing the unchanging relations of natural entities'; in a burst of enthusiasm he declares that, from the point of view he had indicated, 'mathematical analysis is as wide as nature herself,' and 'it increases and grows incessantly stronger amid all the changes and errors of the human mind.' Mathematicians might almost blush with conscious pleasure at such a laudation of their subject from such a quarter, though it errs by both excess and defect; but the exultation of spirit need not last long. The same authority, when officially expounding to the French Academy the work of Jacobi and of Abel upon elliptic functions, expressed his chilling opinion (it had nothing to do with the case) that 'the questions of natural philosophy, which have the mathemathical study of all important phenomena for their aim, are also a worthy and principal subject for the meditations of geometers. It is to be desired that those persons who are best fitted to improve the science of calculation should direct their labors to these important applications.' Abel was soon to pass beyond the range of admonition; but Jacobi, in a private letter to Legendre, protested that the scope of the science was not to be limited to the explanation of natural phenomena. I have not quoted these extracts by way of even hint of reproach against the author of such a wonderful creation as Fourier's analytical theory

of heat; his estimate could have been justified on a merely historical review of the circumstances of his own time and of past times; and I am not sure that his estimate has not its exponents at the present day. But all history shows that new discoveries and new methods can spread to issues wider than those of their origins, and that it is almost a duty of human intelligence to recognize this possibility in the domain of progressive studies. The fact is that mathematical physics and pure mathematics have given much to each other in the past and will give much to each other in the future; in doing so, they will take harmonized action in furthering the progress of knowledge. But neither science must pretend to absorb the activity of the other. It is almost an irony of circumstance that a theorem, initiated by Fourier in the treatise just mentioned, has given rise to a vast amount of discussion and attention, which, while of supreme value in the development of one branch of pure mathematics, have hitherto offered little, if anything, by way of added explanation of natural phenomena.

The century that has gone has witnessed a wonderful development of pure mathematics. The bead-roll of names in that science—Gauss; Abel, Jacobi; Cauchy, Riemann, Weierstrass, Hermite; Cayley, Sylvester; Lobatchewsky, Lie—will on only the merest recollection of the work with which their names are associated show that an age has been reached where the development of human thought is deemed as worthy a scientific occupation of the human mind as the most profound study of the phenomena of the material universe.

The last feature of the century that will be mentioned has been the increase in the number of subjects, apparently dissimilar from one another, which are now being made to use mathematics to some extent. Perhaps the most surprising is the application of mathematics to the domain of pure thought; this was effected by George Boole in his treatise 'Laws of Thought,' published in 1854; and though the developments have passed considerably beyond Boole's researches, his work is one of those classics that mark a new departure. Political economy, on the initiative of Cournot and Jevons, has begun to employ symbols and to develop the graphical methods; but there the present use seems to be one of suggestive record and expression, rather than of positive construction. Chemistry, in a modern spirit, is stretching out into mathematical theories; Willard Gibbs, in his memoir on the equilibrium of chemical systems, has led the way; and, though his way is a path which chemists find strewn with the thorns of analysis, his work has rendered, incidentally, a real service in coordinating experimental results belonging to physics and to chemistry. A new and generalized theory of statistics is being constructed; and a school has grown up which is applying them to biological phenomena. Its activity, however, has not yet met with the sympathetic good-will of all the pure biologists; and those who remember the quality of the discussion that took place last year at Cambridge between the biometricians and some of the biologists will agree that, if the new school should languish, it will not be for want of the tonic of criticism.

If I have dealt with the past history of some of the sciences with which our section is concerned, and have chosen particular epochs in that history with the aim of concentrating your attention upon them, you will hardly expect me to plunge into the future. Being neither a prophet nor the son of a prophet, not being possessed of the knowledge which enabled Halley to don the prophet's mantle with confidence, I shall

venture upon no prophecy even so cautious as Bacon's—'As for the mixed mathematics, I may only make this prediction, that there can not fail to be more kinds of them as nature grows further disclosed'—a declaration that is sage enough, though a trifle lacking in precision. Prophecy, unless based upon confident knowledge, has passed out of vogue, except perhaps in controversial politics; even in that domain, it is helpless to secure its own fulfilment. Let me rather exercise the privilege of one who is not entirely unfamiliar with the practice of geometry, and let me draw the proverbial line before indulgence in prophetic estimates. The names that have flitted through my remarks, the discoveries and the places associated with those names, definitely indicate that, notwithstanding all appearance of divergence and in spite of scattered isolation, the sum of human knowledge, which is an inheritance common to us all, grows silently, sometimes slowly, yet (as we hope) safely and surely, through the ages. You who are in South Africa have made an honorable and an honored contribution to that growing knowledge, conspicuously in your astronomy and through a brilliant succession of astronomers. Here, not as an individual, but as a representative officer of our brotherhood in the British Association, I can offer you no better wish than that you may produce some men of genius and a multitude of able workers who, by their researches in our sciences, may add to the fame of your country and will contribute to the intellectual progress of the world.

A. R. FORSYTH.

SCIENTIFIC BOOKS.

Catalogue of the Lepidoptera Phalænæ in the British Museum, London. Vol. IV., Noctuidæ (part), 1903; Vol. V., Noctuidæ (continued), 1905. By Sir GEORGE F. HAMPSON, Bart.

This is a continuation of the monographs of the moths of the world, of which Vol. III. was noticed in SCIENCE, N. S., XV., 99, 1901. A notice of Vol. IV. will be found in the *Canadian Entomologist,* XXXVI., 27, 1904. Volume V., now before us, consists of 634 pages and treats of 2,073 species of Noctuidæ, comprising the subfamily Hadeninæ. These moths have unspined hind tibiæ and hairy eyes, and are familiar to us under the name *Mamestra* and allies. But these familiar names are again largely changed, unavoidably, no doubt, but we fear that the changes are not permanent. Even if subsequent authors can be induced to respect Sir George Hampson's selections of the types of the older genera, we doubt if he will be generally followed in defining no genera on secondary sexual characters. This is done generally in other families of Lepidoptera and the characters prove very useful. We think some of the genera as used in the volume before us would stand subdivision, *Polia,* for example, which contains 209 species. This would save the old genus *Mamestra,* which now sinks as a synonym of *Polia.* These remarks apply to the other volumes as well and are a criticism on the general system adopted. It is not to be expected that the system could be changed during the progress of the work.

A number of our North American species, particularly those recently described, sink as synonyms. This is mostly perfectly justified, as there has been a tendency recently to describe too many forms as species in the Noctuidæ. This tendency has received a just rebuke.

On page 24, *Scotogramma* is marked as a 'new' genus, no doubt by an oversight.

On page 178 all the forms of *comis* and *olivacea* fall together into the synonymy. I believe this is going a little too far, as I think there can be distinguished two species, though closely allied. Otherwise my contention about these forms is sustained.

On page 267 the name *Chabuata velutina* is used. It should be *Chabuata lutina. Velutina* was preoccupied when described and the author very properly changed the name. The

fact that Hampson has removed it to another genus does not invalidate the change, which was proper when made. He has here violated the rule 'Once a synonym, always a synonym.'

Page 366. The distribution of the genus *Morrisonia* is remarkable. Twenty-eight species are known, twenty-two in New Zealand, six in the United States, and none anywhere else in the world. Of the United States species, five are eastern, only one being western (Arizona). Morrison's species *peracuta,* described as from the United States, is removed to the next genus and becomes a synonym of a New Zealand species, the United States locality being regarded as erroneous.

Page 403, my species *Perigrapha achsha* is omitted (*Can. Ent.,* XXXVI., 32, 1904).

On page 596, *Leucania rubripallens* is credited to Kaslo, British Columbia. I did not find the species there (*Proc. U. S. Nat. Mus.,* XXVII., 863, 1894), and I believe that this is a case of misidentification. The synoptic table on page 594 is bad, the contrasts given under a^3 and b^3 are variable and valueless. *L. rubripallens* separates from *oxygale* and *minorata* by the redder color of the fore wings only, not by the degree of black shading on the hind wings. It occurs in the dry regions of Colorado and Utah and I believe does not occur in the wet wooded district of Kaslo.

On page 610, *Himella infidelis* is made synonymous with *Eriopyga conar* and marked 'non descr.' I do not object to the synonym, even if I do not agree to it, but the species certainly was described (*Can Ent.,* XXXVI., 32, 1904).

Harrison G. Dyar.

SCIENTIFIC JOURNALS AND ARTICLES.

The leading article in the June number of the *American Geologist* is entitled 'The Fossil Turtles of the Bridger Basin,' by O. P. Hay, who states that hitherto geologists Cope, Powell, Emerson and King considered these beds as lake deposits, but his own conclusion is that they have 'been made almost wholly through river action.' Professor S. W. Williston says, concluding his article 'On the Lansing Man,' 'I am only confident that the skeleton dates from Pleistocene times—and is old.' Professor Warren Upham contributes an article on the 'Age of the St. Croix Dalles,' and G. A. Waring one on 'The Pegmatyte Veins of Pala, San Diego County, California,' which is illustrated by five plates and two figures. Professor J. A. Bownocker in discussing 'The Salt Deposits of Northeastern Ohio,' concludes 'that Ohio contains enough salt to supply the entire country for an indefinite period.' A paper on 'Mineralogical Synonyms' is inserted, taken from the *Mineralogical Magazine* for May. The number concludes with an interesting editorial by Dr. G. P. Merrill on 'The New Building for the National Museum, at Washington, D. C.,' which is illustrated by a plate presenting the central plan.

SOCIETIES AND ACADEMIES.

CLEMSON COLLEGE SCIENCE CLUB.

The 54th regular meeting of the club was held in the lecture room of the electrical laboratory, April 28, at 8 P.M. It was the occasion of the ninth annual meeting and banquet. There were present, in addition to the regular members of the club, delegates from other colleges in South Carolina and from the U. S. Department of Agriculture. The program consisted of numbers taken from the preceding programs of the club during the current year, and an informal address on certain phases of agricultural education by Assistant Secretary of Agriculture W. H. Hays. After the regular meeting, the annual banquet was served in the new museum in agricultural hall, and the banquet was made the occasion of the dedication of the museum.

The 55th regular meeting of the club was held in the lecture room of the electrical laboratory at 8:30 P.M., May 19. Professor J. S. Newman, under the title of 'Fifty Years of Agriculture,' discussed the advances in practical agriculture within that time, taking a somewhat pessimistic attitude in regard to what had actually been accomplshed. Professor F. T. Dargan, under the title of 'An Undescribed Method of Demonstrating Horizontal Objects,' made a demonstration of his

apparatus and method, exhibiting Ewing's experiment for demonstrating Weber's molecular theory of magnetism, and showing the magnetic field by use of iron filings. The apparatus, which was very simple, is described as follows: The object to be exhibited is placed on a base (which in the speaker's apparatus consisted of a 60 by 75 centimeter drawing-board covered with white paper). Against two nails driven into this base near the back a large plane mirror is placed, and inclined forward at any desired angle by means of a wire attached to the top of the mirror and passing through a binding post screwed into the back of the base. To each upper corner of the mirror is clamped a 50-candle-power General Electrical Company 'stereopticon' lamp protected in front by metal half shades. These brilliantly illuminate the object and obviate shadows. The apparatus can, of course, be made permanent by hinging the mirror to the base and fastening the lights permanently. It will be seen that the apparatus has many applications in the teaching of the biological as well as physical sciences in exhibiting objects that can not be turned on their edge. The apparatus has the advantage over the projecting lantern with horizontal attachment, first that it does not require a darkened room; second, opaque objects can be exhibited; third, the size of the object to be exhibited is limited only by the size of the mirror; fourth, the apparatus is not only easy to operate, but can be put together from materials usually found in any laboratory.

At the close of the regular meeting, the annual business meeting was held. The annual report of the secretary was received. The following officers were elected for the ensuing year:

President—Professor F. S. Shiver.
Vice-President—Professor S. W. Reaves.
Secretary—Dr. F. H. H. Calhoun.
Members of Council—Dr. J. H. James and Professor F. T. Dargan.

HAVEN METCALF,
Secretary.

SPECIAL ARTICLES.

ASSORTATIVE MATING IN MAN.

As was pointed out in *Biometrika,* Vol. II., No. 4, 1903, "Darwin has given the name of sexual selection to the general conception of differential mating. As opposed to pure random mating within the population, we have first *preferential* mating, in which male or female classes with certain values of a character find it less easy to mate than other classes with different values. Secondly, we have *assortative mating,* in which, while all classes of males and females find mates, certain classes of males appear to be attracted to certain classes of females. If the male class of a given character tends to mate with a female class with generally like character we have a tendency to *homogamy.* Homogamy as one type of assortative mating is simply measured by the correlation between the two characters in the male and female of the pair. The influence of homogamy on the character of successive generations of a population may be very great indeed, and the whole range of effect from pure random matings to perfectly homogamous unions within a population is almost but not quite as important as the difference between self and cross fertilization in plants. It has the distinctive features as compared with self fertilization, that (1) it may have any degree of intensity, (2) it may be confined to special characters, and (3) it is not complicated by any of the supposed harmful effects of inbreeding."

In the paper from which the paragraph I have just quoted was taken we dealt with assortative mating in man with respect to a character—longevity—concerning which there could not possibly be any *conscious* selection. The characters dealt with by Pearson in former papers[1] are also—at least, probably—not made the object of conscious selection. The coefficients of correlation between man and wife in all these cases average about .2—or 'husband and wife are as much alike as uncle and niece, and probably as much alike as, if not more alike than, first cousins.'

[1] *Phil. Trans.*, Vol. 187, A, p. 273, and Vol. 195, A, p. 113; *Biometrika*, II., p. 353.

It seemed to me to be of interest, now, to test the strength of assortative mating with respect to a character in which there is known to be *conscious* selection. The ages of the two members of the pair at once suggested itself. It possesses an added interest because of the former work upon the age at death. I accordingly tabulated the ages of twenty-five hundred couples as given at the marriage license office at Chicago during the spring of 1904. Grouped in three-year classes they are as shown in table.

The data are a little unsatisfactory because of the unfortunate but undeniable proneness of humanity to a lapse of honesty in the matter of age, especially in this connection.

TABLE OF AGE AT MARRIAGE.

WIFE.

HUSBAND.	13–15	16–18	19–21	22–24	25–27	28–30	31–33	34–36	37–39	40–42	43–45	46–48	49–51	52–54	55–57	58–60	
16–18		2															2
19–21	1	113	147	25	5	3											294
22–24		76	334	169	32	4	4	1									620
25–27		59	217	197	101	20	3	1	1								599
28–30		14	74	117	100	52	16	3	4	2							382
31–33		3	21	35	48	34	20	7	4	4							176
34–36		2	13	26	29	23	21	11	3	5	4		1	1			139
37–39		1	2	12	16	15	9	8	15		6	3	1	1			89
40–42		1	3	7	10	8	4	9	10	8	1		2				63
43–45				4	2	5	6	6	6	5	6	2		1			43
46–48				1	3	3	3	2	4	5	3	2	2				28
49–51				2	1	2		4	1	3	2	4	4	2	1		26
52–54			1			3	1	2	1	2	3	4	1	1	1		20
55–57										2	2		1		2		7
58–60				2						2		1	1	1	1	2	10
61–63														1			1
64–66															1		1
	1	271	812	597	347	172	87	54	49	38	27	16	13	8	6	2	2500

So that the figures, instead of telling the exact truth, show us the state of things, modified somewhat by man's ideas of how he thinks they had better be. This undoubtedly raises the coefficient of correlation slightly. It possibly also accounts for some of the extreme skewness of the curve for the wife's age.

However that may be, the coefficient of correlation between the ages of man and wife, as given, is .764. If this be compared with that of stature (.280), span (.199), forearm (.198) or longevity (.223), it will make it possible to appreciate more clearly the precise extent of the unconscious assortative mating.

The writer has on hand data which show that this principle applies to certain insects and spiders as well as to man. So that we are doubtless dealing here with a real biological factor as well as one of sociological interest.

FRANK E. LUTZ.
STATION FOR EXPERIMENTAL EVOLUTION,
COLD SPRING HARBOR, N. Y.

CURRENT NOTES ON METEOROLOGY.

PROGRESS OF KITE AND BALLOON METEOROLOGY.

A FEW years ago no one would have foreseen that a regular publication would be started in 1904, devoted to the physics of the free air, and even to-day scientific men generally must be surprised to see the quantity and the quality of the contributions which deal with the meteorological conditions of the free air. A recent number of the *Beiträge zur Physik der freien Atmosphäre* (No. 3, 1905), besides the paper on cyclonic and anticyclonic temperatures by Clayton, mention of which was recently made in these notes, contains a study of the results obtained during synchronous kite flights from Berlin and Hald (Jutland) from the summer of 1902 to the spring of 1903, and also a short note, by Professor Hergesell, on recent observations on the meteorological conditions of the high warm stratum of air which was first noticed

by Assmann and Teisserenc de Bort at an altitude of about 11 kms. Recent observations during a *ballon-sonde* flight from Strassburg (February 9, 1905) prove the existence of an easterly current at great altitudes, which is independent of the lower currents. The temperature conditions of this upper air stratum show that vertical currents are practically absent, and its high relative humidity suggests some interesting speculations as to its origin.

METEOROLOGICAL ACTIVITY IN ENGLAND.

THE Council of the Royal Meteorological Society of England is about to undertake an extended campaign with a view to advancing the general knowledge of meteorology. A series of lectures is planned, to be of a practical nature, usually illustrated by lantern slides, and to be given by lecturers, appointed by the council, at different places. When possible, exhibits of meteorological instruments are to be made, especially at the shows of the various agricultural societies. The authorities in charge of the 'Agricultural Education in Elementary Schools Bill,' now before Parliament, have been approached with a view to the inclusion of meteorology among the subjects taught in such schools. The scheme as a whole provides for bringing meteorological knowledge to the doors of societies and institutions all over Great Britain. It is also proposed to hold conferences in London, at which delegates from various societies shall be invited to speak. The whole plan shows a healthy activity on the part of the Royal Meteorological Society.

TROPICAL CYCLONES.

THE cyclones of the tropics are of universal interest because of their violence; they are of peculiar interest to meteorologists because of their importance as phenomena having the closest relations to human life and safety, and because of the doubt as to their origin, which gives them an added attraction in the mind of the student. One of the noteworthy efforts to come to a fuller understanding of the frequency, tracks and wind movements in tropical cyclones is a recent paper by A. Schück, of Hamburg, entitled 'Zur Kenntniss der Wirbelstürme' (Hamburg, 1905, 4to, pp. 48). This account is accompanied by a large number of illustrations, including some most interesting pressure curves, although the diagrams are crudely drawn and rather difficult to make out.

CLIMATIC CHANGES IN CENTRAL AFRICA.

A GOOD deal of evidence has been adduced within the last two or three years regarding a desiccation of the lakes of central Africa, and the view has come to be somewhat generally held that a distinct change to a drier climate is in progress. Now comes the report (*Globus*, No. 5, 1905) that Lake Rukwa, to the east of Lake Tanganyika, has risen within two years. Such contradictory reports show the need of great caution in jumping at conclusions of climatic change. Periodic changes in the amount of annual rainfall are well known, but they do not indicate permanent climatic changes progressively in one direction.

COTTON-GROWING IN TROPICAL AUSTRALIA.

THE evolution of a marketable type of cotton which has been named *caravonica*, adapted for growth in the climate of Queensland, holds out the hope of a large cultivation of cotton not only in Queensland, but through the whole of the tropical section of Australia north of latitude 18° S. (*Bull. Amer. Geogr. Soc.*, XXXVII., No. 4, 1905).

HURRICANES, COCOA TREES AND EXPORTS OF GUAM.

A RECENT report, 'Contributions from the United States National Herbarium,' Vol. IX., by W. E. Safford, under the special title, 'The Useful Plants of Guam,' notes the damage done by hurricanes which pass near the island of Guam. In 1900, the destruction caused by two hurricanes resulted in a dearth of food, and nearly $10,000 was spent by the government for the relief of the natives. One of the most serious results is the stripping of cocoa trees of their leaves, which may cause a failure of the trees to produce. In 1901, after the hurricanes above noted, not an ounce of copra was produced in Guam, this being practically the only export of the island.

EXPOSURE AND CROPS IN SWITZERLAND.

NUMBERLESS examples may be given to show the difference of exposure, on southern and northern slopes, upon the vegetation. A recent striking illustration is noted in *La Géographie*, No. 3, 1905, and described in the *Bulletin of the American Geographical Society* for July. Above the hamlet of Findelen, near Zermatt, in the Alps, barley and rye are grown at an altitude of 6,900 feet above sea level, on a sunny southern slope. On the northern slopes, a few hundred yards distant, there is an arctic-alpine flora, with patches of snow lying below the level of the fields of grain on the southern slope.

R. DEC. WARD.

ACTA OF THE INTERNATIONAL CONVENTION OF THE INTERNATIONAL CATALOGUE OF SCIENTIFIC LITERATURE.

OPENING meeting: Tuesday, July 25, at 11 A.M., at the rooms of the Royal Society.

1. Professor Darboux moved that Professor H. E. Armstrong be the chairman of the convention. The motion having been carried unanimously, Professor H. E. Armstrong took the chair and welcomed the delegates.

2. On motion of the chairman, at the request of the Royal Society, Mr. A. B. Kempe, treasurer of the Royal Society, and Dr. L. Mond, member of the executive committee, were invited to take part in the deliberations of the convention.

3. On the motion of the chairman it was resolved: That Dr. J. Deniker be the secretary for the French language; Professor Dr. August von Böhm, secretary for the German language; Cav. E. Mancini, secretary for the Italian language, and Dr. H. Forster Morley, secretary for the English language.

4. On the motion of the chairman, seconded by Dr. Stejneger, it was resolved: That, in view of the success already achieved by the International Catalogue of Scientific Literature and of its great importance to scientific workers, it is imperative to continue the publication of the catalogue at least for a further period of five years.

5. On the motion of the chairman, seconded by M. Darboux, it was resolved that Dr. H. Forster Morley be reappointed director of the catalogue at a salary of £500 per annum.

6. On the motion of the chairman, seconded by Dr. Deniker, it was resolved: That the convention authorizes the annual expenditure of a sum not exceeding £2,000 (in addition to the director's salary), for carrying on the work of the Central Bureau.

Second meeting: Wednesday, July 26, at 10 A.M., at the rooms of the Royal Society.

7. On the motion of M. Darboux it was resolved: That in view of the resolution arrived at to continue the catalogue for a further period of five years, the Royal Society of London be requested: (*a*) Again to act as the publishing body; (*b*) to conclude a contract with Messrs. Harrison and Sons to print the catalogue on the terms indicated in the report of the executive committee; (*c*) to make such provision of working capital as may be desirable in the opinion of the executive committee.

8. On the motion of Dr. Larmor it was unanimously resolved: That as it is undesirable to increase the borrowed capital of the International Catalogue, contracting bodies be informed that in cases where payment in advance is impracticable it is necessary that payment should be made for each volume as soon as possible after delivery. That the director be instructed, in making such special requests for payment as the executive committee may determine, to send a copy of this resolution with his request.

9. On the motion of the chairman it was resolved: That the convention approves of the proposal for an amalgamation of the *Zoological Record* published by the Zoological Society of London with Volume N of the International Catalogue in accordance with paragraph 24 of the report, and authorizes the executive committee to carry the proposal into effect.

10. On the motion of Dr. Stejneger it was resolved: That it is the desire of this convention that the executive committee, as soon as practicable, take into consideration the question of issuing cards.

11. On the motion of Dr. Stejneger, seconded by Dr. Deniker, it was resolved: That

the reports of the committee of schedules be adopted.

12. On the motion of the chairman it was resolved: That the report of the executive committee be adopted and that all matters therein not dealt with by this convention be remitted to the executive committee with power to act thereon.

13. On the motion of Professor Korteweg, seconded by Dr. Deniker, it was resolved that thanks be given to Professor Armstrong for presiding over the convention.

HENRY E. ARMSTRONG, D. G. MÉTAXAS,
OSKAR UHLWORM, J. DENIKER.
D. J. KORTEWEG, D. PRAIN,
AUGUST V. BÖHM, R. NASINI,
LEONHARD STEJNEGER, ERNESTO MANCINI,
I. BORODIN, K. MATSUBARA,
ROLAND TRIMEN, G. DARBOUX,
PAUL OTLET, FRANCISCO A. DE ICAZA,
H. LA FONTAINE, J. LARMOR.

SCIENTIFIC NOTES AND NEWS.

MAJOR RONALD ROSS and Dr. Rubert Boyce, of the Liverpool School of Tropical Medicine, have arrived in this country to cooperate with the authorities at New Orleans in suppressing the epidemic of yellow fever.

SIR PATRICK MANSON, medical adviser to the English colonial office, arrived at San Francisco on August 14 to deliver a course of lectures on tropical diseases at the Lane Hospital.

PROFESSOR JOHN M. COULTER and Dr. H. C. Cowles have leave of absence from the University of Chicago, and expect to spend the autumn and winter in Europe, returning to the university in April. Professor Charles R. Barnes, who has been spending six months in Europe, will return to Chicago for the autumn quarter.

DR. OLIVER L. FASSIG, of the U. S. Weather Bureau and the Johns Hopkins University, has returned to this country from his Arctic voyage in search of Captain Fiala.

DR. W. WYSSLING, professor of electrical engineering in the Zurich Polytechnicum, was expected to arrive in New York this week to study developments of electrical engineering.

MR. JESSE M. GREENMAN, of Harvard University, has been appointed assistant curator of the Department of Botany of the Field Columbian Museum.

DR. R. VON WETTSTEIN, professor of botany at the University of Vienna, has been elected a member of the Academy of Sciences at Madrid.

WE learn from *The British Medical Journal* that Dr. Paul Richer, member of the French Académie de Médecine, and one of the editors of the *Iconographic de la Salpêtrière,* has been elected a member of the Paris Academy of Fine Arts. Dr. Richer is professor of anatomy at the Ecole des Beaux Arts, but he owes the honor which has been conferred upon him to his distinction as a sculptor.

THE *Pharmaceutical Journal* says that the research fellowship in chemistry offered by the Company of Salters, and tenable in the research laboratory of the Pharmaceutical Society, has this year been awarded to Miss Nora Renouf, who has been engaged in original investigations for the past two years in the society's laboratories as holder of the Redwood and the Burroughs scholarships.

Nature states that the editorship of the 'Fauna of British India,' rendered vacant by the death of Dr. W. T. Blanford, has been offered by the secretary of state for India to Lieut.-Colonel C. T. Bingham.

A MEMORIAL window has been placed in St. John's in the Wilderness, Paul Smith's, in the Adirondacks, in memory of the late Dr. Edward L. Trudeau, Jr.

DR. LOUIS H. LAUDY, tutor in general chemistry in Columbia University, died in New York on August 17. Dr. Laudy was a fellow of the American Association for the Advancement of Science and of the New York Academy of Sciences.

DR. LYMAN HALL, president of the Georgia School of Technology, Atlanta, died on August 17 at the age of forty-five years. He was a graduate of the West Point Military Academy and became professor of mathematics in the Georgia School of Technology in 1888.

M. Bichat, professor of physics and dean of the faculty at Nancy, died on July 26, at the age of sixty years. He was a correspondent of the Paris Academy of Sciences, and a member of the council of public instruction.

Mr. Christopher Heath, a well-known British surgeon, emeritus professor of clinical surgery in University College, London, died on August 8, at the age of seventy years.

Professor L. Errera, who held the chair of botany at the University of Brussels, died on August 1.

It is reported in the daily papers that a seventh satellite of Jupiter has been observed at the Lick Observatory.

The first telegraphic longitude station in Labrador has been established at Chateau Bay by Dr. Otto Klotz, Dominion astronomer, in conjunction with Sir William Macgregor, governor of Newfoundland.

The International Congress of Anatomy was opened at Geneva, on August 7, in the presence of 300 representatives of the principal universities of Europe and America. Dr. Eternod, of Geneva, delivered the opening speech. The meeting then entered upon the business to be dealt with, under the presidency of Mr. Symington, of Belfast. The congress has accepted the invitation to assemble at Boston in 1907.

The seventh meeting of the International Congress of Hydrology, Climatology, Geology and Physical Therapeutics will be opened at Venice on October 10 under the honorary presidency of the Italian Minister of Public Instruction, and the acting presidency of Professor A. De Giovanni, of the University of Padua, senator of Italy.

The International Earthquake Conference met at Berlin on August 15. Dr. Theodor Lewald, who was the German commissioner general to the St. Louis Exposition, was elected chairman.

The Latin American Scientific Congress was opened on August 8, delegates from all the South American Republics being present.

The ninth Northern Congress of Schoolmasters was opened in the town-hall at Copenhagen, on August 10. There were present about 7,000 schoolmasters, teachers, instructors and professors, Denmark sending 3,500, Sweden over 2,000, Norway 1,000, and Finland nearly 400. Teachers of every kind are represented, from the poorest village schoolmasters to university professors.

The membership enrolment of the National Educational Association at the forty-fourth annual meeting, held at Asbury Park, from July 3 to 7, is officially reported to be 20,941.

We learn from *The Botanical Gazette* that a new botanical institute, well arranged for research and instruction, has recently been completed for Professor R. Wettstein in the Imperial Botanical Gardens in Vienna.

The *British Medical Journal* states that a medical group has recently been formed in the Italian Parliament. The members are Drs. Agnetti, Angiolini, Baccelli, Badaloni, Basetti, Botteri, Cacciapuoti, Campi, Cantarano, Casciani, Castellino, Ciartoso, Faranda, Fazzi, Fede, Gatti, Lampiasi, Licata, Maresca, Masini, Masselli, Pianese, Queirolo, Rampoldi, Rummo, Sanarelli, Santini, Santoliquido, Scellingo and Tinozzi. The new group, which recently held its first meeting, will direct its efforts to influencing all legislation relating to public health and the legitimate interests of the medical profession. Under the auspices of the group, a general congress of the medical practitioners, poor-law medical officers, pharmacists and veterinarians of Italy, to discuss questions affecting professional interests, will be held in Rome in November.

The *Annales de l'Institut Pasteur* state that the number of persons treated for hydrophobia in Paris during the year 1904 was 755, of whom three died, the rate of mortality being .39 per cent. For the last ten years the rate of mortality has ranged from .18 per cent. in 1902 to .39 per cent. in 1897 and 1904. The department of the Seine (Paris) furnished the largest contingent (233) of persons bitten, the departments which came next in order being the Finistère (50), the Corrèze (28), the Vendée (27), the Loire Inférieure (26), the Lot (25), the Cher and the Deux Sèvres (21).

The final results of the Russian census of 1897 are still appearing at intervals. Among

the latest figures published by the Statistical Department are the following: The total population of the Russian empire (excluding Finland), on May 10, 1897, was 126,586,525. Of these 87,123,604 were members of the Orthodox Church. Old Believers and other sections number 2,204,596; Mahomedans, 13,906,972; Roman Catholics, 11,467,994; Jews, 5,215,805; Protestants (Lutherans), 3,572,653. A division of the population on the basis of classes gives the following results: Hereditary nobles, 1,220,169; nobles for life, or by virtue of office, 630,119; priests of all Christian denominations, 588,947; honorable citizens, 342,927; merchants, 281,179; burgesses, 13,386,392; peasants, 96,896,648; Cossacks, 2,928,842; foreigners, 8,297,965 (this figure includes considerable numbers of the subject population). Illiterates numbered 99,070,436 (79 per cent.); literates, 26,569,585. Students at the universities and other institutions for higher education numbered 104,321.

ACCORDING to a report, made by Dr. E. O. Hovey, for the U. S. Geological Survey, the production of salt in the United States during 1904 was 22,030,002 barrels (of 280 pounds), valued at $6,021,222, as compared with 18,968,089 barrels, valued at $5,286,988 in 1903. This is the largest production ever reported except in 1902, but the average net price per barrel (27.332 cents) is lower than that reported in 1903 (27.873 cents) or in any previous year, with the exception of 1902, when the average net price realized was only 23.769 cents a barrel. The most noteworthy feature of the year 1904 was the increase of 1,193,620 barrels in the production of rock salt. This increase was due in large part to the expansion of the salt industry of Louisiana, where rock salt is easily and cheaply mined in the 'mounds' which occur in the southern part of the state. The chief salt-producing States are New York and Michigan, and the combined output from these two States amounts to about two-thirds of the total production of the United States. The five leading salt-producing states during 1904 were New York, 8,600,656 barrels (39.04 per cent.); Michigan, 5,425,904 barrels (24.63 per cent.); Ohio, 2,455,829 barrels (11.15 per cent.); Kansas, 2,161,819 barrels (9.81 per cent.), and Louisiana, 1,095,850 barrels (4.97 per cent.). The actual consumption of salt in 1904 was 23,116,971 barrels, or about 2.46 times what it was in 1880. The imports of salt in 1904 amounted to 332,279,481 pounds. Great Britain contributed 98,943,611 pounds, worth $301,696; Italy 106,060,288 pounds, valued at $75,756; Canada 11,102,273 pounds, valued at $27,529; West Indies 105,160,371 pounds, worth $89,878; and other countries 20,882,959 pounds, valued at $20,371. The total value of all the imported salt was thus $515,230. It will be observed that while the value of the salt imported from Great Britain was more than 58.5 per cent. of the total value of imports for the year, the quantity received from that country was only about 28.9 per cent. of the total amount of salt imported. The West Indies and Italy both exceeded Great Britain in the quantity of salt exported to the United States, but it was all of coarse grades, and consequently of low valuation.

A PRESS bulletin of the Forest Service says that the annual value of the staves, hoops and heads made by the mills of the United States is over $20,000,000. It is estimated that more than 300,000 barrels, kegs, tubs and similar articles are manufactured daily in the United States. Until a very recent date the woods chiefly used for cooperage were the slow-growing hardwoods such as oak, elm, maple, ash, beech and birch, but within the last few years cottonwood, poplar, and latterly gum, have been substituted to some extent, owing to the diminishing supply of the species first exploited. The depletion of the supply of raw material is felt strongly by the manufacturer, who finds it yearly more difficult to obtain good stock. This is especially true for white oak, since the maker of tight cooperage must often refuse stock which a furniture maker would consider first-class material. Two factors have contributed to bring about this condition—first, the increase in the cooperage manufacture, which has developed enormously in the past quarter century; and, second, the extremely wasteful methods employed in cutting, which have left the forest in a deplorable condition, and often wasted more material than

was used. Cutting for cooperage purposes is far more wasteful than is ordinary lumbering. The Forest Service in taking up this question aims to make its investigations of practical value to the cooperage industry and its operators. It is planned to bring together information regarding the supply of raw material, and the best methods of manufacture, and the ill effects of wasteful methods on the forest and possible remedies for them. Particular attention will also be given to a study of the properties of woods, with the view of recommending substitutes which are more abundant than the species now used for cooperage.

A Parliamentary paper has been issued containing the report of his majesty's astronomer at the Cape of Good Hope to the secretary of the admiralty for the year 1904. According to an abstract in the London *Times* the report makes a sympathetic reference to the death of Mr. Frank McClean, to whose generosity the observatory owes the Victoria telescope, with its observatory, dome and many valuable adjuncts. After referring to the work in connection with the new transit circle and the new sidereal clock, the report states that owing to an unfortunate accident, which occurred during the absence of the regular observers, the driving worm and sector of the Victoria telescope were damaged, and the moving portion of the instrument, including the Polar axis and telescope tubes, had to be raised in order to remove the damaged sector. The driving worm of the sector and slow-motion gear were sent to Sir Howard Grubb for alteration and repair early in November. Sir Howard Grubb promised to send off the repaired sector by the end of January, together with an electromotor giving 'quick slow motion' in R.A., a much-needed adjunct for facilitating the placing of the image of the star on the slit. In consequence of this accident the new objective prism had not yet been tested. Details of astronomical observations are given, and the report says that the astronomer has, at the request of the Colonial governments, generally superintended the geodetic survey of South Africa and taken a prominent part in the preparation of arrangements for the establishment of a central office to complete the geodetic and topographic survey of British South Africa south of the Zambesi. The negotiations for that purpose are now nearly completed, and the whole will be placed under the charge of Colonel Morris, whose name has so long and so honorably been connected with the survey of South Africa. Though the admiralty is not connected with this important work, details of the proceedings of the past year are included in this report, as no other record of its progress is issued.

UNIVERSITY AND EDUCATIONAL NEWS.

Dr. Eli McClish has resigned the presidency of the University of the Pacific.

Mr. C. M. Jansky, of the Bureau of Standards, formerly of the University of Michigan, has been appointed professor of electrical engineering at the University of Oklahoma.

Mr. Albert S. Ritchey, of Indianapolis, Ind., has been appointed assistant professor of railroad engineering at the Worcester Polytechnic Institute.

Dr. J. E. Ives, of the De Forest Wireless Telegraph Company, has been appointed assistant professor of physics in the University of Cincinnati.

Dr. W. M. Twitchell has been appointed professor of geology in South Carolina College.

The Psychological Bulletin states that Dr. Williston S. Hough, formerly of the University of Minnesota, has been appointed professor of philosophy in George Washington University.

Dr. Thomas W. Mitchell, instructor in accounting and finance in the University of Pennsylvania, has been appointed assistant professor of finance and accounts in the School of Commerce in New York University to succeed Professor Henry W. Mussey, who goes to Bryn Mawr College.

Mr. George F. Lamb has been appointed professor of biology in Mt. Union College, Ohio.

Dr. Wilhelm Deeke has been promoted to a chair of mineralogy at Griefswald.